FINAL REPORT FOR
CANAVERAL HARBOR, FLORIDA
MAINTENANCE DREDGING 103 EVALUATION-2000
ADDITIONAL SAMPLING AND TESTING FOR
EXTENSION OF EPA CONCURRENCE

DELIVERY ORDER 0046
CONTRACT DACW17-97-D-0001

MAY 2000

SUBMITTED TO:

U.S. Department of the Army
Corps of Engineers, Jacksonville District
P.O. Box 4970
Jacksonville, Florida 32232-0019

SUBMITTED BY:

PPB Environmental Laboratories, Inc.
6821 S.W. Archer Road
Gainesville, Florida 32608

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Table of Contents

Appendices

Tables

Figures

EXECUTIVE SUMMARY

During the period March 2 and 3, 2000, ten sample stations in Canaveral Harbor, Florida, were sampled as part of the Canaveral Harbor 1999 Maintenance Dredging 103 Evaluation. This evaluation is a required follow-up to an evaluation for ocean disposal of dredged material done for Canaveral Harbor in 1999.

The elutriate test results indicated that after 96 hours of exposure to elutriates from the Canaveral Harbor area, survival of *Menidia beryllina* in the control water (0% elutriate) was significantly different (P=0.05) from survival in three of the site sediments (E-CH00-4&6, E-CH00-7&8, and E-CH00-7&8 duplicate). These samples were also significantly different from the control sediment (100% elutriate).

The whole sediment test results indicated that after 10 days of exposure to sediments from the Canaveral Harbor area, there were no significant differences (P=0.05) in the survival of *Mysidopsis bahia* among the samples.

After 10 days of exposure to sediments from the Canaveral Harbor area, there were significant differences (P=0.05) in the survival of *L. plumulosus* between the laboratory control sediment and four site samples (E-CH00-4&6, E-CH00-5, E-CH00-7&8, and E-CH00-7&8 duplicate). There were also significant differences (P=0.05) in the survivorship of *L. plumulosus* between the field reference sediment and these same four site sediments. Note that all the stations with low survivorship for the various species used were collected from the Navy Trident Basin.

1.0 INTRODUCTION

This report presents the results of our physical, chemical, and biological analysis of sediment and water samples from Canaveral Harbor as part of the 2000 Maintenance Dredging 103 Evaluation. Elutriate bioassay data and sediment bioassay data are included. Sediment samples were collected during the period March 2 and 3, 2000 at ten sample stations. These samples were composited such that eight samples were prepared for testing. Also presented are data from an area reference station consisting of two substations located near the Canaveral ODMDS.

2.0 METHODS AND MATERIALS

2.1 Sample Collection Techniques

All sediment samples were collected either as grab samples or as cores using a vibracoring device. Details are as follows:

Station	Sediment Collection Technique
E-CH00-1	Vibracoring
E-CH00-2	Van Veen Grabs
E-CH00-3	Van Veen Grabs
E-CH00-4	Van Veen Grabs
E-CH00-5	Van Veen Grabs
E-CH00-6	Van Veen Grabs
E-CH00-7	Van Veen Grabs
E-CH00-8	Van Veen Grabs
E-CH00-9	Van Veen Grabs
E-CH00-10	Van Veen Grabs
RS-CH99-1	Van Veen Grabs
RS-CH99-2	Van Veen Grabs

Sediment samples were properly labeled, iced, and then transported to the laboratory via surface transportation.

Station locations are shown in the enclosed site maps (see Figures 1 and 2).

2.2 *In Situ* Field Measurements

Hydrographic measurements for water temperature, pH, water depth, turbidity, dissolved oxygen, turbidity, salinity, and conductivity were made using a Hydrolab Scout 2 and a Hach Model 2100P turbidimeter. Field observations were made concerning sea state, tidal cycle, and weather.

2.3 Sediment Analyses

After thorough mixing of each entire sediment sample (to maximize homogeneity), portions of the sample were prepared and shipped to Environmental Science and Engineering, Inc. for bioassay testing. All testing was performed in accordance with published procedures.

Figure 1. Canaveral Harbor Stations Sampled March 2 and 3, 2000

Figure 2. Canaveral Harbor Reference Stations Sampled March 2, 2000

2.4 Bioassays

2.4.1 GENERAL PROCEDURES

Elutriate bioassays were conducted on sediments collected from the Canaveral Harbor area to determine the potential impact of dissolved and suspended contaminants on organisms exposed to the elutriate after conducting an initial mixing period. The test organism used for the elutriate tests was the inland silverside, *Menidia beryllina*.

Sediment bioassays were conducted to determine the acute effects of the site contaminants on the infaunal amphipod, *Leptocheirus plumulosus* and the mysid shrimp, *Mysidopsis bahia*. Sediment bioaccumulation tests were also conducted with the polychaete, *Nereis virens* and the bivalve, *Macoma nasuta*.

All bioassays were conducted in accordance with the U.S. Environmental Protection Agency and the U.S. Army Corps of Engineers Standard Testing Manual entitled: *Evaluation of Dredged Material for Proposed Ocean Disposal - Testing Manual* (USEPA-503/8-91/001, February 1991).

The test samples (seven site sediments, one duplicate sediment, and one reference sediment) were collected March 2-3, 2000 and were received at the ESE Toxicology Laboratory on March 7, 2000. Approximately 10 gallons of control sediment was collected by ESE personnel from the Atlantic Ocean, near Marineland, Florida, on March 8, 2000. The control sediment has been successfully used in previous tests conducted at ESE and was used for all the bioassay tests. All samples were stored in a refrigerator at 4 ± 2 ^{o}C until used, and unused portions of test samples were stored similarly during the testing period. Sample chain-of-custody and other traffic information are provided in Appendix A-1.

Test sediments were received in quantities of approximately 5 gallons each with the exception of sample E-CH00-9&10, of which approximately 3 gallons were received and used for bioaccumulation testing only. Prior to use in testing, sediments were thoroughly homogenized in their original containers and sifted or hand-sorted to remove any organic debris, small rocks, and indigenous organisms.

2.4.2 ELUTRIATE BIOASSAY PROCEDURES

The *M. beryllina*, used in the elutriate bioassays, were received from Aquatic Indicators, St. Augustine, Florida, and were 8 days old at test initiation. The elutriate bioassays were conducted at the ESE Toxicology Laboratory from March 9-12, 2000 using laboratory control sediment, sediments E-CH00-1 through E-CH00-7&8, and the duplicate site sample.

Natural filtered seawater, collected from the Atlantic Ocean near Marineland, Florida, was used as dilution and laboratory control water. The seawater was adjusted to a salinity of 25 parts per thousand (ppt) prior to use in preparing the three different elutriate concentrations for the *M. beryllina* tests. Five replicates each of the three elutriate concentrations (10%, 50% and 100%) of the six site sediments, the E-CH00-7&8 duplicate site sediment, and laboratory control sediment were tested. The laboratory control water was also tested as 0% elutriate. Elutriates were not prepared from the field reference sample. The *M. beryllina* tests were conducted in 600-mL beakers containing 400 mL of elutriate or control solution. Ten organisms were placed in each of the five replicate test chambers. *M. beryllina* were fed brine shrimp nauplii (*Artemia* sp.) to excess during holding prior to test initiation. All tests were performed at a temperature of 20 $\pm$ 1 ^{o}C and under ambient laboratory illumination (~740 lux).

Elutriates were prepared by mixing 1 part of sediment to 4 parts of water to achieve a sediment-to-water ratio of 1-to-4 by volume. The mixtures were mechanically stirred for 30 minutes at room temperature on a magnetic stirrer with additional mixing by hand every 10 minutes. The mixtures were allowed to settle for at least 1 hour and then the supernatant was siphoned off as the 100% elutriate. Dilutions of the 100% elutriate were made to obtain the 50% and 10% elutriates on a volume-to-volume basis.

Water quality parameters measured daily during the 96-hour *M. beryllina* tests were D.O., pH, temperature, and salinity. Dissolved oxygen was measured with a YSI Model 55 DO meter, temperature was measured with a VWR thermocouple, pH was measured with an Orion Model SA 290A pH meter, and salinity was measured with an Aquatic Eco-systems CL893 refractometer. All instruments were calibrated daily before use. Survival counts were performed daily and at test conclusion for the *M. beryllina* elutriate tests.

Steel's Many One Rank Test was used to compare mean survivorship in the control sediment (100% elutriate) or the control elutriate (0% elutriate) versus the 100% elutriate from each of the Canaveral Harbor site sediments. Steel's Many One Rank Test is the nonparametric test recommended by the guidance when the data are found to violate the assumption of normality, and which are found not to be normalized by data transformations. Median lethal concentration (LC_{50}) values were calculated, if necessary. The LC_{50} is defined as the concentration of elutriate or reference toxicant that kills or inhibits fifty percent of the exposed test organisms under the specified conditions of exposure. The LC_{50} values for all of the sediment elutriates with less than 50% mortality were estimated as greater than 100% in accordance with EPA guidelines (EPA/503/8-91/001).

2.4.3 SEDIMENT BIOASSAY PROCEDURES

Two test species were used for the sediment bioassays, *Leptocheirus plumulosus* and *M. bahia*. Juvenile *L. plumulosus* (2-4 mm in length, with no mature males) were obtained from Aquatic Research Organisms, Hampton, Hew Hampshire, and *M. bahia* (3 days old at test initiation) were obtained from Aquatic Indicators, Inc. (St. Augustine, FL).

The 10-day sediment tests with *L. plumulosus* and *M. bahia* were conducted March 17-27, 2000, with a daily photoperiod of 16-hour light and 8-hour dark cycle under fluorescent lighting conditions (~840 lux) for the duration of the tests.

The sediment tests were conducted at the ESE Toxicology Laboratory using five replicates each for the: (1) laboratory control sediment, (2) E-CH00-7&8 duplicate site sediment, (3) one reference sediment, and (4) the six site sediments, E-CH00-1 through E-CH00-7&8, from Canaveral Harbor. Test chambers were 1.5-liter glass jars for the *L. plumulosus* test and 1.6 liter glass Carolina bowls for the *M. bahia* test. Twenty *M. bahia* or *L. plumulosus* were loaded in each of the five replicate test chambers at test initiation. All test chambers were aerated at approximately 60-80 bubbles per minute. Aeration was supplied to the test chambers using an oil free laboratory air compressor (Aquatic Eco Systems, Inc., Clearwater, Florida) through flexible Tygon tubing fitted with glass pipette tips. During testing, *M. bahia* were fed three drops per replicate of brine shrimp nauplii (*Artemia* sp.) twice daily to prevent cannibalism. *L. plumulosus* were not fed for the duration of the 10-day exposure period.

Water quality parameters measured daily during the 10-day *M. bahia* and *L. plumulosus* whole sediment tests were D.O., pH, temperature, and salinity. Dissolved oxygen was measured with a YSI Model 55 DO meter, temperature was measured with a VWR thermocouple, pH was measured with an Orion Model SA 290A pH meter, and salinity was measured with an Aquatic Eco-systems CL893 refractometer. Total ammonia was measured at 48-hour water renewals with an SA 290A meter equipped with an Orion 95-12 ammonia probe and light intensity was measured with a lux meter. All instruments were calibrated daily before use. Survival counts were performed at test termination for all *L. plumulosus* and *M. bahia* sediment tests.

Prior to test initiation (Day-1), natural seawater (salinity of 25 ppt for *M. bahia* and 28 ppt for *L. plumulosus*) and sediments were introduced to each test chamber at a ratio of 1 part sediment to 4 parts seawater and allowed to settle overnight. The overlying water was siphoned from each of the replicate test chambers after 24 hours and new overlying water was added. Water quality parameters were measured immediately prior to adding the test organisms. Water renewals were performed at 48-hour intervals immediately after taking water quality measurements. Water was siphoned from the test chambers and placed in a glass beaker to determine that inadvertent removal of test organisms had not occurred. Any test organisms inadvertently siphoned out were immediately returned to their test chambers. Clean seawater was added back into the test chambers, taking care not to resuspend the sediment. Dead brine shrimp were removed from the *M. bahia* test chambers on a daily basis.

Sediment bioassay data were evaluated by a statistical comparison of mean survivorship in the sample station sediment relative to the field reference or laboratory control average survivorship, using Dunnett's t-Test procedure (EPA/600/4-89/001). Data were first checked for normality and homogeneity of variance using Shapiro-Wilk's and Bartlett's tests, respectively. If either of these assumptions was not met, the data were transformed using a square-root arcsine transformation or another transformation resulting in normalization prior to analysis by Dunnett's procedure.

2.5 Bioaccumulation Procedures

The polychaete, *N. virens*, and the bivalve, *M. nasuta* used in the bioaccumulation study were obtained from Aquatic Research Organisms, Hampton, New Hampshire.

The bioaccumulation tests were performed for 28-days (from March 15 through April 12, 2000 for *N. virens* and *M. nasuta*) using five replicates each of sediments E-CH00-1 through E-CH00-9&10, the reference, the E-CH00-7&8 duplicate sediments, and the laboratory control sediment. Each replicate test chamber was a 10-gallon aquarium to which a minimum of 2 centimeters (depth) of sediment were added. Each of the exposure aquaria was filled with approximately 8 gallons natural seawater with a salinity of 25 $\pm$ 2 ppt. Twenty *N. virens* and 20 *M. nasuta* were then added to each test chamber (the two species were tested in separate tanks). Test organisms were not fed at any time during the testing period.

The tests were performed in a temperature-controlled room adjusted to maintain a constant test temperature of 18 $\pm$ 2 ^{o}C, and under laboratory illumination (~1050 Lux). Aeration was provided to all of the test chambers at approximately 100-120 bubbles per minute with the aid of an oil-free laboratory air compressor (Aquatic Eco Systems, Inc., Clearwater, Florida).

Water quality parameters measured daily during the 28-day whole sediment bioaccumulation tests were D.O., pH, temperature, and salinity. Dissolved oxygen was measured with a YSI Model 55 DO meter, temperature was measured with a VWR thermocouple, pH was measured with an Orion Model SA 290A pH meter, and salinity was measured with an Aquatic Eco-systems CL893 refractometer. All instruments were calibrated daily before use. Observations were made daily for organism behavior and mortality. Survival counts were performed at test termination for all of the bioaccumulation tests.

Renewals of the overlying water in the aquaria were performed three times per week. Water was siphoned from the aquaria through 11/16-inch (outside diameter) Tygon tubing and the aquaria were refilled with seawater pumped from a holding tank through similar tubing. The Tygon tubing, equipped with plastic pinch clamps and tipped with plastic T-joints, was connected to PVC pipes fitted with control valves to adjust the flow of water. Care was taken to ensure that the sediment in each tank was not disturbed during renewals.

After 28 days of exposure, test organisms from each replicate were removed from the aquaria and allowed to depurate in clean seawater for 24 hours. After depuration, organisms from each replicate were rinsed in deionized water, placed into Ziploc bags, and stored in a freezer at -10 $\pm$ 2 ^{o}C. Frozen *N. virens* and *M. nasuta* tissues were archived for shipment to PPB Environmental Laboratories, Inc., Gainesville, Florida, for chemical analyses (if required).

3.0 RESULTS AND DISCUSSION

3.1 Field Data

Results of water column measurements and field observations are presented in Tables 1 and 2. Sampling occurred from March 2 and 3, 2000 when water temperatures ranged from 19.4 to 21.6EC. Dissolved oxygen ranged from 4.1 to 7.5 mg/L, while the range for pH was 7.77 to 8.14. Turbidity ranged from 1.3 to 14.0 NTUs. Salinity and conductivity ranged from 35.1 to 36.7 ppt and from 53.1 to 55.3 mmhos/cm, respectively. Weather conditions were sunny, with calm to moderate winds. Sea state varied from calm to a light chop.

3.2 Bioassay Data

Test conditions for the *M. beryllina* elutriate bioassay tests, including temperature, DO and pH levels, were maintained at acceptable levels throughout the testing period. Salinities for some of the test samples slightly exceeded the recommended test range on Days 3 and 4 (up to 32 ppt for sample E-CH00-2); however, the test organisms did not appear to be affected by the salinity variation. Complete laboratory raw data are provided in Appendix A-2.

Menidia beryllina

Survivorship data from elutriate bioassays of control water (0% elutriate), control elutriate, eight sample stations, and one duplicate station are presented in Table 3. Survivorship of *M. beryllina* was 92% in the control water (0% elutriate) and 90% in the control sediment (100% control) elutriate. Test station sample survivorship ranged from 0% (100% elutriate from sample stations E-CH00-7&8 and E-CH00-7&8 Duplicate) to 92% (50% elutriate from sample stations E-CH00-1 and E-CH00-2) (Table 3).

Based on the results of the survival counts, there were significant differences (P=0.05) in the survivorship of *M. beryllina* between the control water (0% elutriate) and survivorship in the 100% elutriate concentration prepared from the site sediments for E-CH00-4&6, E-CH00-7&8, and E-CH00-7&8 duplicate (Table 4). These same samples were also significantly different (P=0.05) in the survivorship of *M. beryllina* between the control sediment (100% elutriate) and survivorship in any of the different elutriate concentrations (Table 5).

Median Lethal Concentration

Exposure of *M. beryllina* to elutriates prepared from sediments from the six sample stations and one duplicate station resulted in less than 50% mortality in all of the elutriate bioassays except stations E-CH00-7&8, and E-CH00-7&8 duplicate. Consequently, the LC_{50} values for the *M. beryllina* tests were all estimated to be greater than 100% except for E-CH00-7&8 (LC_{50} = 17%), and E-CH00-7&8 duplicate (LC_{50} = 35%) in accordance with EPA/503/8-91/001 (Table 6).

Table 1. Results of *In Situ* Hydrographic Measurements at Canaveral Harbor on March 2 and 3, 2000

Station ID	Coordinates	Date and Time	Depth (feet)	Tidal Cycle	Sea State	Weather
RS-CH00-1	28°20.100'N 80°29.845'W	03/02/00 1031	51	Low	Light chop	Sunny, wind SW at 10 kts
RS-CH00-2	28°17.463'N 80°29.582'W	03/20/00 0932	54	Low	Light chop	Sunny, wind SW at 10 kts
E-CH00-1	28°25.034'N 80°37.418'W	03/02/00 1500	10	Incoming	Calm	Sunny, wind SW at 10-15 kts
E-CH00-2	28°25.077'N 80°37.538'W	03/02/00 1659	34	High	Calm	Sunny, wind SW at 10 kts
E-CH00-3	28°24.963'N 80°37.499'W	03/02/00 1745	39	Outgoing	Calm	Sunny, wind SW at 10 kts
E-CH00-4	28°25.115'N 80°35.666'W	03/03/00 1421	43	Incoming	Calm	Sunny, wind SE at 10 kts
E-CH00-5	28°25.022'N 80°35.745'W	03/03/00 1435	43	Incoming	Calm	Sunny, wind SE at 10 kts
E-CH00-6	28°24.958'N 80°35.668'W	03/03/00 1400	43	Incoming	Calm	Sunny, wind SE at 10 kts
E-CH00-7	28°24.762'N 80°35.660'W	03/03/00 1520	44	Incoming	Calm	Sunny, wind SE at 10 kts
E-CH00-8	28°24.676'N 80°35.552'W	03/03/00 1605	45	Incoming	Calm	Sunny, wind E-SE at 10-15 kts
E-CH00-9	28°24.862'N 80°37.438'W	03/03/00 0911	39	Low	Light chop	Sunny, patchy fog, wind W-SW at 15 kts
E-CH00-10	28°24.680'N 80°37.448'W	03/03/00 0942	38	Low	Light chop	Sunny, wind W-SW at 10-15 kts

Table 2. Depth Profile *In Situ* Data from Canaveral Harbor Collected March 2 and 3, 2000

Station ID	Sampling Depth (feet)	Temp (EC)	pH (Units)	Dissolved O_2 (ppm)	Salinity (ppt)	Conductivity (mmhos/cm)	Turbidity (NTU)
RS-CH00-1	1	20.2	8.08	6.3	36.1	54.6	1.8
	25	20.0	8.08	6.3	36.0	54.5	2.1
	50	19.8	8.03	5.3	36.0	54.4	5.6
RS-CH00-2	1	20.5	8.04	6.2	36.1	54.5	1.3
	28	20.4	8.03	6.2	36.0	54.4	1.6
	54	20.0	8.00	5.6	35.9	54.3	5.0
E-CH00-1	1	21.6	8.14	6.6	35.1	53.2	3.8
	6	19.8	8.12	6.0	35.5	53.7	3.6
	10	19.8	8.11	6.0	35.6	53.8	3.6
E-CH00-2	1	21.2	8.14	6.6	35.1	53.1	3.1
	16	19.6	8.03	4.5	35.7	53.8	3.4
	32	19.4	8.01	4.1	35.9	54.1	2.8
E-CH00-3	1	20.4	8.10	6.1	35.3	53.4	3.0
	20	19.6	80.1	4.6	35.6	53.8	6.4
	38	19.6	8.00	4.7	35.7	53.9	6.9
E-CH00-4	1	21.0	7.92	7.0	35.8	54.0	1.6
	23	19.8	7.85	4.7	36.6	55.1	4.0
	42	20.0	7.84	4.5	36.7	55.2	6.5
E-CH00-5	1	21.0	7.93	7.4	35.9	54.1	1.8
	20	19.7	7.81	4.7	36.5	55.0	3.7
	42	19.9	7.81	4.6	36.7	55.3	6.8
E-CH00-6	1	20.9	7.86	7.0	35.8	54.1	2.2
	21	19.9	7.80	5.1	36.5	55.0	5.2
	42	20.0	7.77	4.8	36.6	55.2	8.0
E-CH00-7	1	20.7	8.00	7.5	36.0	54.3	2.9
	21	19.8	7.89	5.0	36.5	55.0	5.2
	43	20.0	7.92	5.6	36.7	55.3	7.8
E-CH00-8	1	20.8	8.05	7.0	35.9	54.1	3.3
	21	19.9	8.00	5.4	36.5	54.9	5.4
	44	20.0	7.99	5.4	36.5	55.1	14.0
E-CH00-9	1	19.8	7.95	5.6	35.8	54.0	3.4
	20	19.7	7.93	5.0	36.0	54.3	3.9
	38	19.9	7.94	5.0	36.1	54.5	5.6
E-CH00-10	1	19.9	7.92	5.6	35.7	53.9	2.8
	17	19.7	7.89	4.8	36.0	54.3	5.2
	37	20.0	7.91	4.8	36.3	54.8	6.3

ıble 3. 96-Hour *Menidia beryllina* Survival in Three Elutriate Concentrations Prepared from Sediments Collected from Canaveral Harbor, March 2000 (Page 1 of 3)

Sample	**Replicate**	**Number of Survivors**		
CONTROL (seawater)	A	9		
	B	9		
	C	8		
	D	10		
	E	10		
	Total	46		
	Percent	92%		
Sample	**Replicate**	**Elutriate Concentration**		
		10%	50%	100%
CONTROL SEDIMENT	A	8	10	9
	B	9	9	8
	C	9	8	9
	D	9	9	10
	E	10	10	9
	Total	45	46	45
	Percent	90%	92%	90%
E-CH00-1	A	10	10	8
	B	9	9	6
	C	10	10	9
	D	6	7	10
	E	9	10	10
	Total	44	46	43
	Percent	88%	92%	86%
E-CH00-2	A	8	9	10
	B	10	10	7
	C	7	10	10
	D	9	9	9
	E	8	8	7
	Total	42	46	43
	Percent	84%	92%	86%

Sample	**Replicate**	**Elutriate Concentration**		
E-CH00-3	A	7	10	10
	B	10	9	9
	C	9	8	9
	D	7	7	8
	E	8	8	9
	Total	41	42	45
	Percent	82%	84%	90%
E-CH00-4&6	A	6	4	6
	B	9	7	3
	C	9	8	6
	D	6	6	6
	E	7	7	5
	Total	37	32	26
	Percent	74%	64%	52%
E-CH00-5	A	8	6	6
	B	9	6	8
	C	9	7	6
	D	7	4	8
	E	7	4	8
	Total	40	27	36
	Percent	80%	54%	72%
E-CH00-7&8	A	0	2	0
	B	7	2	0
	C	6	5	0
	D	8	3	0
	E	7	1	0
	Total	28	13	0
	Percent	56%	26%	0%

Sample	**Replicate**	**Elutriate Concentration**		
E-CH00-7&8 Duplicate	A	4	7	0
	B	6	3	0
	C	6	4	0
	D	6	5	0
	E	7	4	0
	Total	29	23	0
	Percent	58%	46%	0%

Table 3. 96-Hour *Menidia beryllina* Survival in Three Elutriate Concentrations Prepared from Sediments Collected from Canaveral Harbor, March 2000 (Page 1 of 3)

Sample	Replicate	Number of Survivors
CONTROL (seawater)	A	9
	B	9
	C	8
	D	10
	E	10
	Total	46
	Percent	92%

Sample	Replicate	Elutriate Concentration		
		10%	50%	100%
CONTROL SEDIMENT	A	8	10	9
	B	9	9	8
	C	9	8	9
	D	9	9	10
	E	10	10	9
	Total	45	46	45
	Percent	90%	92%	90%
E-CH00-1	A	10	10	8
	B	9	9	6
	C	10	10	9
	D	6	7	10
	E	9	10	10
	Total	44	46	43
	Percent	88%	92%	86%
E-CH00-2	A	8	9	10

Table 3. 96-Hour *Menidia beryllina* Survival in Three Elutriate Concentrations Prepared from Sediments Collected from Canaveral Harbor, March 2000 (Page 1 of 3)

B	10	10	7
C	7	10	10
D	9	9	9
E	8	8	7
Total	42	46	43
Percent	84%	92%	86%

Sample	Replicate	Elutriate Concentration		
E-CH00-3	A	7	10	10
	B	10	9	9
	C	9	8	9
	D	7	7	8
	E	8	8	9
	Total	41	42	45
	Percent	82%	84%	90%
E-CH00-4&6	A	6	4	6
	B	9	7	3
	C	9	8	6
	D	6	6	6
	E	7	7	5
	Total	37	32	26
	Percent	74%	64%	52%
E-CH00-5	A	8	6	6
	B	9	6	8
	C	9	7	6
	D	7	4	8
	E	7	4	8
	Total	40	27	36
	Percent	80%	54%	72%
E-CH00-7&8	A	0	2	0
	B	7	2	0
	C	6	5	0
	D	8	3	0
	E	7	1	0

Total	28	13	0
Percent	56%	26%	0%

Sample	Replicate	Elutriate Concentration		
E-CH00-7&8 Duplicate	A	4	7	0
	B	6	3	0
	C	6	4	0
	D	6	5	0
	E	7	4	0
	Total	29	23	0
	Percent	58%	46%	0%

Table 4. Summary of Steel's Many One Rank Test of Control Seawater and Test Sediment (100% Elutriate) on *M. beryllina* Survival for Canaveral Harbor, March 2000

M. beryllina Control Seawater vs. Other Samples

Steel's Many One Rank Test

Sample ID	Critical Rank Sum	Value	Significant at alpha level of 0.05?	
Control Seawater		Varies	--	--
E-CH00-1 (100%)		25.5	16	No
E-CH00-2 (100%)		25.0	16	No
E-CH00-3 (100%)		25.5	16	No
E-CH00-4&6 (100%)		15.0	16	Yes
E-CH00-5 (100%)		16.5	16	No
E-CH00-7&8 (100%)		15.0	16	Yes
E-CH00-7&8Dup (100%)		15.0	16	Yes

Note: Critical values are one tailed (k=7) for test of null hypothesis that control survival < treatment survival.

Table 5. Summary of Steel's Many One Rank Test of Control Sediment (100% Elutriate) and Test Sediment (100% Elutriate) on *M. beryllina* Survival for Canaveral Harbor, March 2000

M. beryllina Control Sediment (100% Elutriate) vs. Other Samples

Steel's Many One Rank Test

Sample ID	Rank Sum	Critical Value	Significant at alpha level of 0.05?
Control Sediment (100% Elutriate)	Varies	--	--
E_CH00_1 (100%)	27.0	16	No
E_CH00_2 (100%)	26.5	16	No
E_CH00_3 (100%)	27.5	16	No
E_CH00_4&6 (100%)	15.0	16	Yes
E_CH00_5 (100%)	16.5	16	No
E_CH00_7&8 (100%)	15.0	16	Yes
E_CH00_7&8 Dup (100%)	15.0	16	Yes

Note: Critical values are one tailed (k=7) for test of null hypothesis that control survival < treatment survival.

Table 6. LC_{50} (*M. beryllina*) Values for Elutriate Bioassays Conducted on Canaveral Harbor Sediments, March 2000[a]

Sample ID	*M. beryllina*
Control Sediment	>100%
E-CH00-1	>100%
E-CH00-2	>100%
E-CH00-3	>100%
E-CH00-4&6	>100%
E-CH00-5	>100%
E-CH00-7&8	17%
E-CH00-7&8Dup	35%

[a] LC_{50} values recorded as greater than 100% had greater than 50% survival.

Reference Toxicant Tests

Monthly reference toxicant tests were conducted to determine the general health of the test species. The reference toxicant for the *M. beryllina* tests was sodium dodecyl sulfate (SDS) with a test duration of 48 hours. The 48-hour LC_{50} results for *M. beryllina* was 1.89 mg SDS/L (95% confidence limits of 1.53 to 2.32 mg SDS/L). The LC_{50} value is within historical ESE values and indicate that the test organisms were within their normal sensitivity ranges. The reference toxicant data sheets and the LC_{50} calculations for the elutriate tests are presented in Appendix A-3.

3.2.1 SEDIMENT BIOASSAY DATA

Sediment bioassay test conditions, including temperature, D.O., and pH were maintained at acceptable levels throughout the testing period. Salinity variations for the sediment *M. bahia* tests slightly exceeded the recommended test range (up to 31 ppt on Day 9 for sample E-CH00-1); however, the test organisms did not appear to be affected by the salinity variation. Overlying water renewals were performed at 48-hour intervals in an effort to reduce elevated salinity levels. Ammonia was detected in the various samples in varying concentrations ranging from non-detect (<0.1 mg/L as nitrogen) to a maximum concentration of 0.9 mg/L as nitrogen in sample E-CH00-7&8 duplicate in the *L. plumulosus* exposure. The relevant laboratory raw data pertaining to the whole sediment tests are provided in Appendices A-4 and A-5 for *M. bahia* and *L. plumulosus*, respectively.

Mysidopsis bahia

M. bahia survivorship was 96% in the laboratory control sediment and 94% in the field reference sediment (Table 7). Survivorship of *M. bahia* in site sediments ranged from 80% (Station E-CH00-4&6) to 91% (Station E-CH00-3). *M. bahia* survivorship among replicates was relatively uniform and surviving *M. bahia* appeared healthy at test termination.

Data were tested for homogeneity and normality, and transformed, as necessary. Statistical analyses using ANOVA failed to reject the hypothesis that the survival of *M. bahia* was equal in all groups (Table 8). Therefore, additional statistical comparisons were unwarranted.

Leptocheirus plumulosus

L.. plumulosus survivorship was 93% and 83%, respectively, in the laboratory control and field reference sediments (Table 9). Survivorship of *L. plumulosus* in the site sediments ranged from 16% (Station E-CH00-7&8 duplicate) to 85% (Station E-CH00-3). Surviving *L. plumulosus* appeared healthy at the termination of the tests and survivorship among replicates was relatively uniform.

Data were tested for homogeneity and normality, and transformed, as necessary. Statistical analysis using Dunnett's test indicated that the survival of *L. plumulosus* in the laboratory control sediment was significantly different (P=0.05) from survival in samples E-CH00-4&6, E-CH00-5, E-CH00-7&8, and E-CH00-7&8 duplicate. Significant differences (P=0.05) for the survivorship of *L. plumulosus* were also present between the field reference sediment and these same samples (Table 10).

Table 7. 10-Day Sediment *Mysidopsis bahia* Survival, Canaveral Harbor Sediments, March 2000 (Page 1 of 3)

Sample	Replicate	Number of Survivors
CONTROL SEDIMENT	A	19
	B	20
	C	18
	D	19
	E	20
	Total	96
	Percent	96%
REFERENCE SEDIMENT	A	20
	B	19
	C	17
	D	20
	E	18
	Total	94
	Percent	94%
E-CH00-1	A	17
	B	17
	C	19
	D	16
	E	17
	Total	86
	Percent	86%
E-CH00-2	A	17
	B	14
	C	18
	D	19
	E	18
	Total	86
	Percent	86%

E-CH00-3	A	19
	B	18
	C	17
	D	20
	E	17
	Total	91
	Percent	91%
E-CH00-4&6	A	19
	B	15
	C	15
	D	16
	E	15
	Total	80
	Percent	80%
E-CH00-5	A	16
	B	18
	C	16
	D	19
	E	16
	Total	85
	Percent	85%

E-CH00-7&8	A	18
	B	19
	C	17
	D	16
	E	15
	Total	85
	Percent	85%
E-CH00-7&8 Duplicate	A	18
	B	16
	C	18
	D	19
	E	17
	Total	88
	Percent	88%

Table 8. Summary of ANOVA of Control Sediment or Reference Sediment and Test Sediment (Whole Sediment) on *M. bahia* Survival for Canaveral Harbor, March 2000

M. bahia Control vs. Other Samples (Whole Sediment)

ANOVA for Differences Between Means

Source of Variation	df	Sum of Squares	Mean Square	F
Between Means	7	0.078	0.011	2.23
Within Means	32	0.161	0.005	
Total 39	0.239			

Since F is <Critical F do not reject H_o: all groups equal;
Minimum significant difference = 0.1097, with $\forall$ = 0.05, and 32 df.

M. bahia Reference vs. Other Samples (Whole Sediment)

ANOVA for Differences Between Means

Source of Variation	df	Sum of Squares	Mean Square	F
Between Means	7	0.062	0.009	1.67
Within Means	32	0.171	0.005	
Total 39	0.233			

Since F is < Critical F do not reject H_o: all groups equal;
Minimum significant difference = 0.1131, with $\forall$ = 0.05, and 32 df.

Table 9. 10-Day Sediment *L. plumulosus* Survival, Canaveral Harbor Sediments, March 2000 (Page 1 of 3)

SAMPLE	REPLICATE	NUMBER OF SURVIVORS
CONTROL SEDIMENT	A	18
	B	18
	C	20
	D	20
	E	17
	Total	93
	Percent	93%
REFERENCE SEDIMENT	A	17
	B	19
	C	19
	D	17
	E	11
	Total	83
	Percent	83%
E-CH00-1	A	9
	B	16
	C	13
	D	17
	E	17
	Total	72
	Percent	72%
E-CH00-2	A	18
	B	17
	C	15
	D	14
	E	20
	Total	84
	Percent	84%

E-CH00-3	A	13
	B	19
	C	15
	D	19
	E	19
	Total	85
	Percent	85%
E-CH00-4&6	A	10
	B	4
	C	14
	D	7
	E	11
	Total	46
	Percent	46%
E-CH00-5	A	13
	B	10
	C	3
	D	8
	E	11
	Total	45
	Percent	45%
E-CH00-7&8	A	7
	B	5
	C	0
	D	1
	E	14
	Total	27
	Percent	27%

E-CH00-7&8 Duplicate	A	0
	B	1
	C	10
	D	5
	E	0
	Total	16
	Percent	16%

Table 10. Summary of ANOVA and Dunnett's Tests of Control Sediment or Reference Sediment and Test Sediment (Whole Sediment) on *L. plumulosus* Survival for Canaveral Harbor, March 2000 (Page 1 of 2)

L. plumulosus Control vs. Other Samples (Whole Sediment)

ANOVA for Differences Between Means

Source of Variation		Sum of Squares	df	Mean Square	F
Between Means		7	2.931	0.419	12.6
Within Means		32	1.065	0.033	
Total	39	3.996			

Since F is > Critical F reject H_o: all groups equal;
Minimum significant difference = 0.2821, with ∀ = 0.05, and 32 df.

Dunnett's Test

Sample ID	∀ = 0.05	difference between means
Control	--	--
E-CH00-1	=	-0.21
E-CH00-2	=	-0.09
E-CH00-3	=	-0.08
E-CH00-4&6	□	-0.47
E-CH00-5	□	-0.48
E-CH00-7&8	□	-0.66
E-CH00-7&8(Dup)	□	-0.77

Table 10. Summary of ANOVA and Dunnett's Tests of Control or Reference and Test Sediment (Whole Sediment) on *L. plumulosus* Survival for Canaveral Harbor, March 2000 (Page 2 of 2)

L. plumulosus Reference vs. Other Samples (Whole Sediment)

ANOVA for Differences Between Means

Source of Variation	Sum of df	Squares	Mean Square	F
Between Means	7	2.630	0.376	10.4
Within Means	32	1.155	0.036	
Total 39	3.785			

Since F is > Critical F reject H_o: all groups equal;
Minimum significant difference = 0.2938, with ∀ = 0.05, and 32 df.

Dunnett's Test

Sample ID	∀ = 0.05	difference between means
Reference	--	--
E-CH00-1	=	-0.11
E-CH00-2	=	0.01
E-CH00-3	=	0.02
E-CH00-4&6	□	-0.37
E-CH00-5	□	-0.38
E-CH00-7&8	□	-0.56
E-CH00-7&8(Dup)	□	-0.67

Reference Toxicant Tests

Reference toxicant tests were conducted with each species tested in the sediment tests. The reference toxicant used for *M. bahia* was SDS and the duration of the test was 48 hours. The reference toxicant used for *L. plumulosus* was cadmium chloride ($CdCl_2$), measured as Cd, for a duration of 96 hours. The 48-hour LC_{50} results for *M. bahia* was 10.72 mg SDS/L (95% confidence limits of 8.65 to 13.29 mg SDS/L) and the 96-hour LC_{50} results for *L. plumulosus* was 1.53 mg Cd/L (95% confidence limits of 0.78 to 3.17 mg Cd/L). The LC_{50} values were within historical ESE values and indicated that the test organisms were within their normal sensitivity ranges. The reference toxicant data sheets and LC_{50} calculations for the sediment tests are presented in Appendix A-6.

3.3 Bioaccumulation Data

The bioaccumulation test conditions, including temperature, DO, pH, and salinity, were maintained at acceptable levels throughout the 28-day testing period. The laboratory raw data are provided in Appendices A-7 and A-8.

Macoma nasuta

Data for the survival of *M. nasuta* in the bioaccumulation tests are presented in Table 11. *Macoma nasuta* survivorship in the laboratory control and field reference sediments was 81% and 85%, respectively. Survival of *M. nasuta* in the site sediments ranged from 76% (sample station E-CH00-1) to 91% (sample station E-CH00-2) (Table 11). Adequate mass of *M. nasuta* tissue was available for chemical analyses for all of the samples, if required.

Nereis virens

Data for the survival of *N. virens* in the bioaccumulation tests are also presented in Table 11. *Nereis virens* survivorship in the laboratory control and field reference sediments was 97% and 94%, respectively. Survival of *N. virens* in the site sediments ranged from 78% (sample station E-CH00-4&6) to 95% (sample stations E-CH00-1 and E-CH00-7&8 Duplicate) (Table 11). Adequate mass of *N. virens* tissue was available for chemical analyses for all samples, if required.

Table 11. Survivorship of *Macoma nasuta* and *Nereis virens* During 28-Day Bioaccumulation Bioassays with Sediments from Canaveral Harbor, April 2000 (Page 1 of 2)

Sample ID	Replicate[a]	*Macoma nasuta*	*Nereis virens*
Control Sediment	A	17	19
	B	17	20
	C	15	19
	D	16	20
	E	16	19
	Total[b]	81	97
Reference Sediment	A	17	19
	B	17	19
	C	16	20
	D	17	17
	E	18	19
	Total[b]	85	94
Station E-CH00-1	A	15	18
	B	17	19
	C	16	19
	D	14	20
	E	14	19
	Total[b]	76	95
Station E-CH00-2	A	18	20
	B	18	17
	C	18	17
	D	19	20
	E	18	17
	Total[b]	91	91
Station E-CH00-3	A	17	14
	B	17	16
	C	16	17
	D	17	20
	E	12	16
	Total	79	83
Station E-CH00-4&6	A	16	16
	B	20	16
	C	17	17
	D	14	15
	E	15	14
	Total[b]	82	78

Table 11. Survivorship of *Macoma nasuta* and *Nereis virens* During 28-Day Bioaccumulation Bioassays with Sediments from Canaveral Harbor, April 2000 (Page 2 of 2)

Sample ID	Replicate[a]	*Macoma nasuta*	*Nereis virens*
Station E-CH00-5			
	A	17	17
	B	19	19
	C	17	12
	D	16	14
	E	18	19
	Total[b]	87	81
Station E-CH00-7&8			
	A	19	20
	B	18	15
	C	19	19
	D	16	18
	E	15	20
	Total[b]	87	92
Station E-CH00-7&8 Duplicate			
	A	16	20
	B	17	20
	C	17	19
	D	17	18
	E	18	18
	Total[b]	85	95
Station E-CH00-9&10			
	A	16	20
	B	16	18
	C	17	16
	D	16	14
	E	16	17
	Total[b]	81	85

[a] One hundred organisms exposed per sample
[b] Totals represent number alive and percent survival

4.0 REFERENCES

APHA. 1989. Standard Methods for the Analysis of Water and Waste Water. 17th ed. American Public Health Association, American Water Works Association, Water Pollution Control Federation, Washington, DC.

ASTM. 1984. Standard Practice for Conducting Bioconcentration Tests with Fishes and Saltwater Bivalve Mollusks. Standard Practice No. E-1022-84. American Society for Testing and Materials, Philadelphia, PA.

Dixon, W.J. and F.J. Massey. 1969. Introduction to Statistical Analysis. McGraw-Hill Book Co., San Francisco. 638 pp.

Environmental Protection Agency (EPA). 1983. Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020.

Environmental Protection Agency (EPA). 1986. Test Methods for Evaluating Solid Wastes, EPA SW-846, Third Edition.

Environmental Protection Agency (EPA). 1988. Computer Program and Users Guide for Probit and Dunnett's Analysis of Data from Acute and Short Term Chronic Toxicity Tests with Aquatic Organisms. Prepared by Statistical Support Staff, Computer Sciences Corporation. Prepared for the Biological Methods Branch, Environmental Monitoring and Support Laboratory, Cincinnati, OH, 1988.

Environmental Protection Agency (EPA). 1988. Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Marine and Estuarine Organisms. EPA/600/4-87/028.

Environmental Protection Agency (EPA). 1989. Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms. EPA/600/4-89/001.

Environmental Protection Agency (EPA). 1991. Evaluation of Dredged Material Proposed for Ocean Disposal, Testing Manual, EPA-503/8-91/001.

Environmental Protection Agency (EPA) and Department of the Army. 1994. Evaluation of Dredged Material Proposed for Discharge in Waters of the U.S. (Testing Manual - Draft). June. EPA-823-B-94-002.

Gulley, D.D., A.M. Boelter, and H.L. Bergman. 1991. Toxstat 3.3. Department of Zoology and Physiology, University of Wyoming. April 1991.

Hamilton, M.A., R.C. Russo, and R.V. Thurston. 1977. Trimmed Spearman-Karber Method for Estimating Median Lethal Concentrations in Toxicity Bioassays. Environmental Science and Technology. 11(7):714-719; Correction 12(4):417 (1978).

Lee, D.R. 1980. Reference Toxicants in Quality Control of Aquatic Bioassays. Pp. 188–199 in A.L. Buikema, Jr. and J. Cairns, Jr. (Eds.), Aquatic Invertebrate Bioassays. ASTM Spec. Tech. Publ. 715. American Society for Testing and Materials, Philadelphia, PA.

Scott, K.J. and M.S. Redmond. 1989. The Effects of a Contaminated Dredged Material on Laboratory Populations of the Tubiculous Amphipod *Mysidopsis bahia*. ASTM Spec. Tech. Publ. 1027. American Society for Testing and Materials, Philadelphia, PA.

Snedecor, G.W. and Cochran, G.C. 1980. Statistical Methods. Iowa State Univ. Press, Ames, Iowa. 507 pp.

Sokal, R.R. and F.J. Rohlf. 1981. Biometry. W. H. Freeman & Co., San Francisco. 859 pp.

Swartz, R.C., W.A. DeBen, J.K.P. Jones, J.O. Lamberson, and F.A. Cole. 1985. Phoxocephalid Amphipod Bioassay for Marine Sediment Toxicity. Pp. 284–307 in R.D. Cardwell, R. Purdy, and R.C. Bahner (Eds.), Aquatic Toxicology and Hazard Assessment. 7th Symp. ASTM Spec. Tech. Publ. 854. American Society for Testing and Materials, Philadelphia, PA.

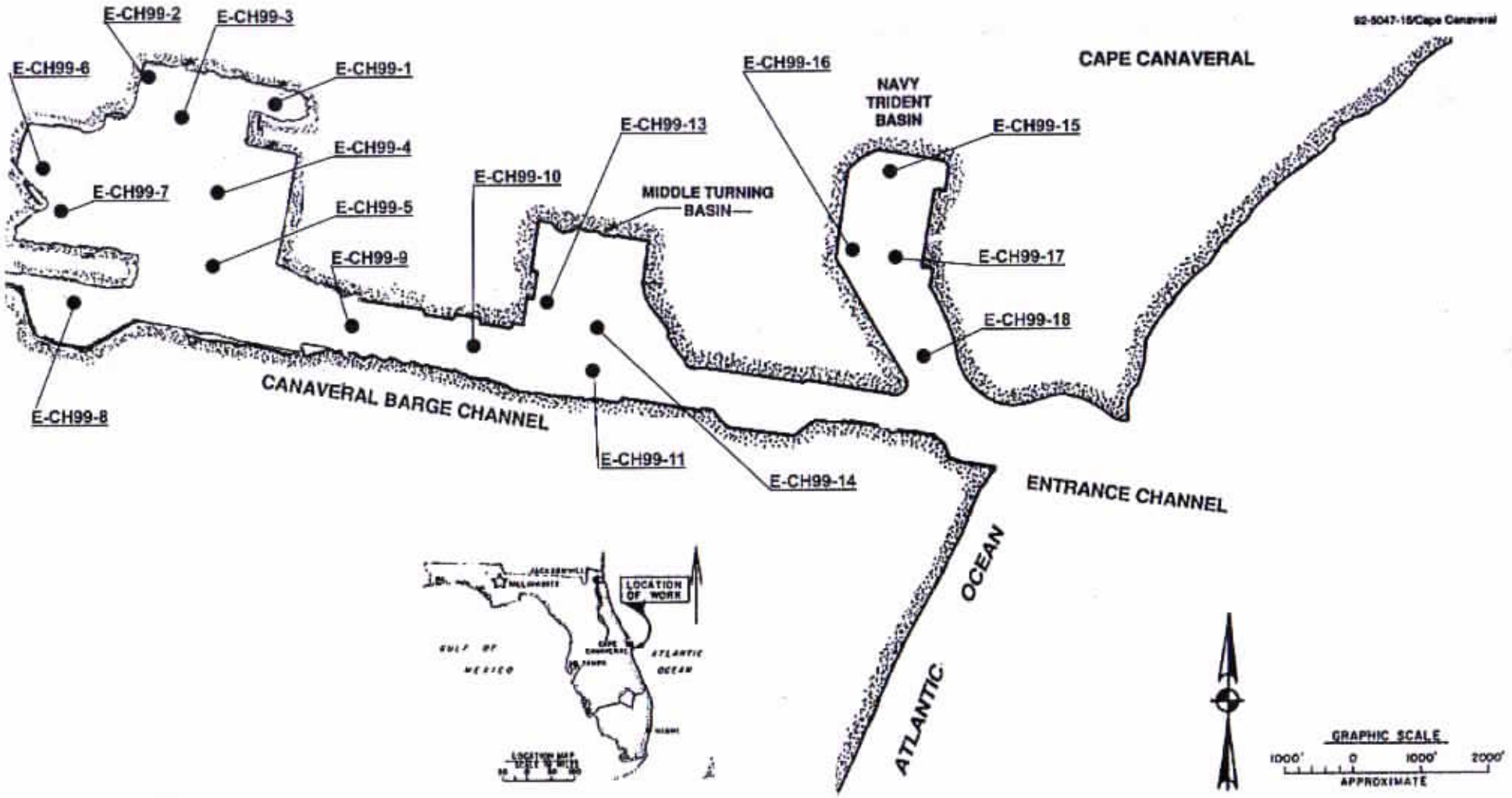

Figure 1

CANAVERAL HARBOR STATIONS SAMPLED NOVEMBER 16 - 19, 1999

ppb ENVIRONMENTAL LABORATORIES, INC.

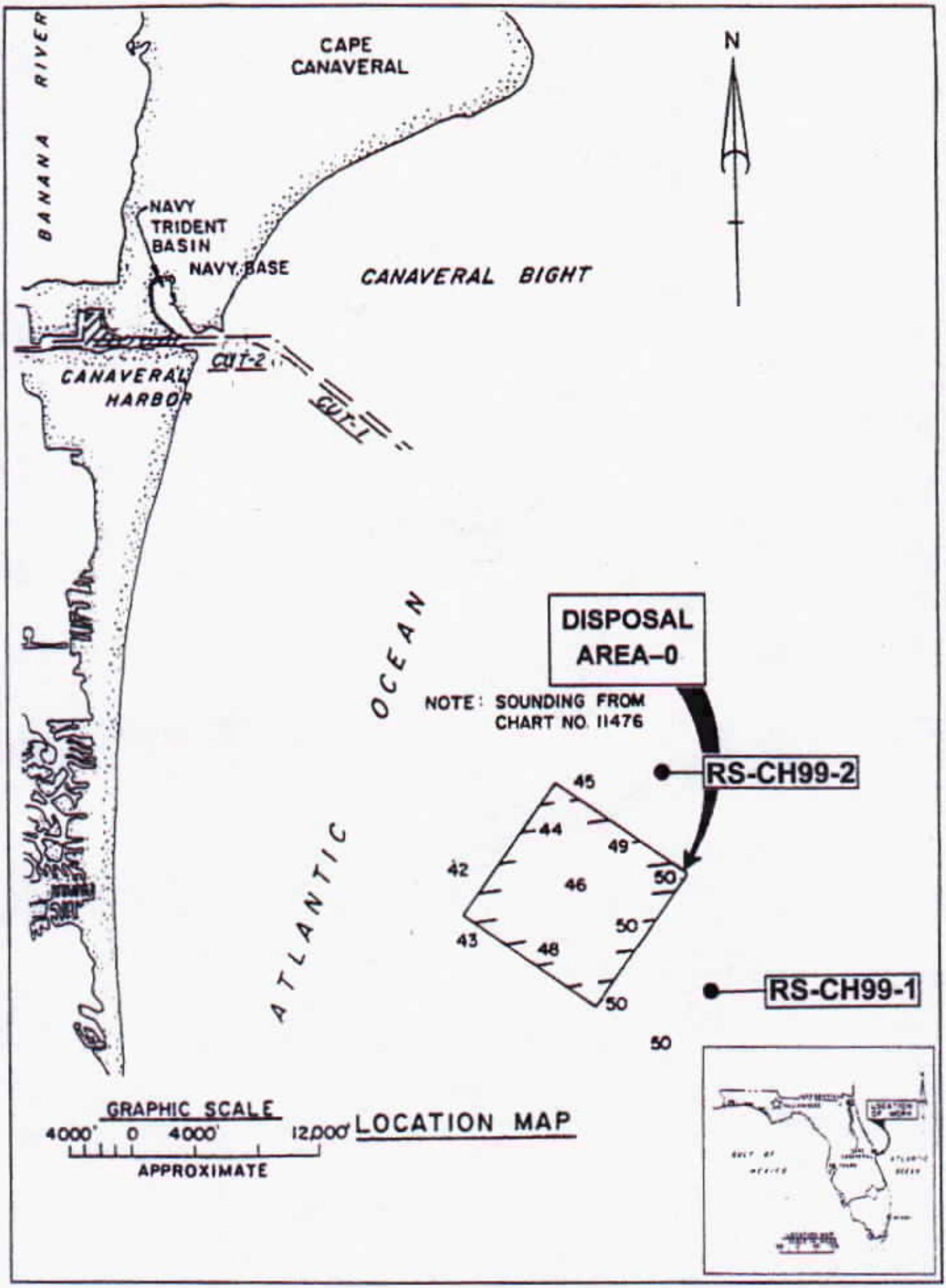

Figure 2. Canaveral Harbor Reference Stations Sampled November 16, 1999